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(54) IMPROVEMENTS IN OR RELATING TO CIRCUIT BOARD EYELET

(71) We, BERG ELECTRONICS, INC., of 142 Reno Street, New Cumberland, Pennsylvania, 17070, United States of America, a Corporation organised under the laws of the State of Pennsylvania, United States of America, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The disclosure relates to an improved miniature circuit board eyelet for holding a lead wire.

In the art it is conventional to form circuit board eyelets by drawing so that the eyelet has a flat head. The drawn eyelet is inserted in a circuit board hole so that the flat head is flush with one side of the circuit board. The other end of the eyelet is then flattened to extend flush against the other side of the circuit board. The lead wire is inserted in the eyelet and the circuit board is solder dipped in order to connect the lead wire to the printed circuitry on the board.

Such conventional eyelets are in general unsatisfactory because the solder joints formed between the flat heads of the eyelets and the circuit board are thin and weak. These joints are liable to crack during cooling, and do not make a reliable electrical connection between the lead wire and the printed circuit on the circuit board. Cracking usually occurs at the joint between the top eyelet flange and the printed circuitry on the top of the circuit board. This type of cracking occurs usually during cooling immediately following solder dipping and results from the difference in the thermal expansion coefficients of the organic circuit board and the metal eyelet. The cracking phenomenon is discussed more fully in Hodges, "Eyelet Failure in Etched Wiring," pp. 109—114, I.R.E. Transactions, Production Techniques, April 1957. The solder connection in conventional eyelets with the circuitry on the top of the circuit board is also found to crack when the soldered circuit board is exposed to thermal shock.

Also, the conventional eyelet does not provide any means for gripping and holding the lead wire once it is inserted in the body of the eyelet. The leads are free to fall out of the eyelet or to change position therein and project downwardly below the surface of the circuit board. In mass production wiring of circuit boards using conventional eyelets it is usual to provide an operator whose sole responsibility is to make sure all the lead wires are in their proper eyelets prior to solder dipping of the board. Additional labour is required to check to be sure that the leads do not extend below the circuit board. In a number of applications there is very slight clearance beneath the circuit board, and short circuiting would result if a lead wire projected any appreciable distance from the bottom of the circuit board.

According to the invention we provide a wire grip circuit board eyelet comprising a hollow cylindrical body shaped to be fitted within an eyelet hole extending through a circuit board, flanges on both ends of said body for holding the body within the circuit board hole, and a plurality of wire grip fingers cut out from said body and extending into the interior of said body in converging relationship with free ends of the fingers grouped together, said fingers being spaced around the circumference of the body in generally pyramidal relation so as to receive and hold a lead wire within the thickness of the circuit board.

The flanges, after staking of the eyelet to the circuit board, preferably project away from the surface of the circuit board at an angle of about 45° to provide an annular vee which is filled with solder during solder dipping. The fingers are preferably connected to one of the flanges so that the fingers and said one of the flanges comprise a spring system for holding a lead wire in the eyelet body. The eyelet preferably includes stress relief pillars spaced

around the circumference of the body and connecting the flanges, the pillars being sufficiently flexible to permit contraction thereof during cooling following a soldering operation.

Also according to the invention we provide a circuit board eyelet comprising a hollow cylindrical body shaped to be fitted within an eyelet hole in a circuit board, and flanges at each end of the body for securing the eyelet in the circuit board hole; said body comprising a plurality of wire grip fingers cut out from the body and extending into the interior thereof in converging relationship with free ends of the fingers grouped together and a plurality of longitudinally extending and circumferentially spaced pillars, the circumferential extent of each pillar being less than the circumferential spacing between adjacent pillars for an axial distance sufficient to prevent movement of said flanges relative to the circuit board upon the occurrence of thermal shock.

An exemplary embodiment of the invention will now be particularly described with reference to the accompanying drawings in which:—

Figure 1 is a perspective view of circuit board eyelets according to the invention, attached to a carrier strip;

Figure 2 is a side view of one of the eyelets shown in Figure 1;

Figure 3 is a top view of Figure 2;

Figure 4 is a sectional view taken along line 4—4 of Figure 3;

Figure 5 is a sectional view through a circuit board showing an eyelet secured thereto prior to insertion of the lead wire and solder dipping;

Figure 6 is a perspective view of a circuit board showing the use of the eyelet;

Figure 7 is a sectional view of two eyelets showing lead wires inserted therein prior to solder dipping;

Figure 8 is a sectional view showing an eyelet after solder dipping; and

Figure 9 is a view of a strip of metal from which the eyelets are formed.

In this description the orientation of the illustrated parts will be assumed to be as shown in the drawings.

A circuit board eyelet 10 according to the invention is preferably formed from sheet metal stock shown in Figure 9 by means of a stamping die. The sheet metal stock, which may be steel, brass, phosphor bronze, beryllium copper, or other suitable metal, is press stamped to provide a carrier strip 12 having pilot holes 14 regularly spaced therealong and eyelet blanks 16 secured to the strip at one side thereof. The blanks 16 are slit as indicated at 18 and punched at 20. In a further die operation the blanks 16 are rolled to form eyelets 10 as illustrated in Figure 1. The rolled eyelets are offset from strip 12 to facilitate attachment of the eyelet to the circuit board. During rolling of the eyelet blank 16 sections 22 of the blanks are bent away from the cylindrical body 24 of the eyelet to provide an outwardly extending circumferential flange 26. The punched holes 20 are located at the bottom of flange 26 adjacent the top of the body 24 of the eyelet. Slits 18 connecting holes 20 to the top of the blank 16 are spread apart during flaring of the flange to provide notches 28 which extend from the outer edge of the flange to the top of the body 24.

Wire grip fingers 30 are formed from the side walls of the body 24 and are connected to the flange 26 at the top of the body portion. The fingers are triangular in shape and extend around the circumference of the body and into the centre of the eyelet in converging relation so that the free ends 32 thereof are grouped together adjacent the lower end of the body 24. The lower flange portion 34 of the eyelet is rolled to form a slightly tapered lead-in to facilitate insertion of the eyelet into a circuit board hole.

As indicated in Figure 4, the flange 26 is bent to an angle of about 50° relative to a plane perpendicular to the axis of the eyelet. The fingers 30 form extensions of the flange 26 and extend therefrom into the interior of the eyelet. The intersection of the flange 26 and fingers 30 with a plane passing through the axis of the cylindrical body 24 is essentially linear. There may be a slight deviation from this linearity due to the fact that the fingers 30 are planar while the flange 26 is curved and has the shape of the side of a truncated cone.

As illustrated best in Figures 2 and 4, the flange 26 and fingers 30 are connected to pillar portions 36 of the body 24 at 38. Each notch 28 is located in flange 26 at the middle of the circumferential extent of one of the fingers. During rolling of the eyelet blank 16 to form the eyelet 10 the opposite edges of the body are brought together at seam 40.

The eyelet 10 may be severed from the strip 12 at 47 and inserted into a hole 42 in circuit board 44. The eyelet is then positioned between staking tools having conical heads which upon closing stake the eyelet to the circuit board as shown in Figure 5. The segmented lower flange portion 34 is flared away from the cylindrical body so that it makes an angle of approximately 45° with the surface of the circuit board. The lower staking head which performs this operation is relieved so that it does not deform the free ends 32 of the wire grip fingers. The upper staking head has a 45° side chamfer so that during staking of the eyelet to the circuit board the flange 26 is bent down toward the surface of the circuit board 5° from an angle of 50° to an angle of 45°. This bending of the flange accomplishes two purposes. First, it brings the fingers closer together and may bring the ends 32 into abutment and cause a slight tensing

of the fingers 30. This adds to the spring resilience of the fingers so that they securely grip a lead wire when it is inserted into the eyelet. Secondly, the bending of the flange 26 assures proper positioning of the eyelet fingers despite the fact that the circuit board hole 42 may be somewhat larger in diameter than the outer diameter of the body 24 of the eyelet. In this case the staking heads will expand the eyelet at seam 40 to snugly fit the oversize hole and the bending of the flange 26 to a 45° angle relative to the surface of the board 44 will again position the ends of the fingers 30 together.

When the eyelet has been attached to the circuit board both the upper and lower flanges make an angle of approximately 45° with the adjacent circuit board surface. The triangular wire grip fingers 30 extend into the eyelet in converging pyramidal relation and substantially close the interior of the eyelet. As shown in Figure 5, both sides of the circuit board may be provided with printed circuit paths 46 adjacent the hole 42 so that after solder dipping a reliable electrical connection is formed between the eyelet and the circuit paths.

After the eyelet has been staked to the circuit board, the exposed ends of lead wire 48 may be inserted into the eyelet either manually or by means of an automatic insertion machine. Because of the small size of the eyelets it is often difficult to insert a lead wire exactly into the circuit board hole. The upper flange 26 serves as a funnel-shaped lead-in for guiding the wire into the eyelet, thereby increasing the target area for insertion. The notches 28 are small in comparison to the diameter of the wire inserted into the eyelet so that there is little likelihood of the end of the wire hanging up on one of the notches during insertion. As the wire is pushed between the ends of the wire grip fingers 30, the fingers are forced outwardly toward the body 24 of the eyelet as illustrated in Figure 7. Since the fingers are connected to the flange 26, the outward flexing of the fingers tends to pivot the flange and fingers about the upper edge of the circuit board hole so that the flat fingers 30 and the rounded flange 26 co-operate to form a spring system urging the fingers into intimate engagement with the end of the lead wire 48. The spring system is secured to the body 24 of the eyelet by joints 38. Due to the flexing of the spring system upon insertion of the lead wire, the flange 26 may make an angle with the circuit board slightly greater than the 45° angle of the flange relative to the circuit board shown in Figure 5.

During insertion of a lead wire into the eyelet the essentially flat fingers 30 may be bent slightly along their length to increase the gripping force for holding the lead wire in the eyelet. Insertion of a lead wire into the eyelet may bend the fingers 30 relative to flange 26 so as to form a slight acute angle with an extension of the flange 26 as opposed to the orientation of the fingers and flange in the eyelet shown in Figure 5 prior to insertion of the lead wire.

As illustrated in Figure 7, one or more lead wires may be inserted and securely held in eyelets according to the invention. The co-operation of the fingers 30 and flange 26 provide a strong spring force urging the fingers into engagement with the lead wires so as to securely grip the same and hold them in the inserted position. Thus the eyelet 10 prevents lead wires from falling out of the eyelet or from slipping through the eyelet and extending below the lower surface of the circuit board 44. The ability of the circuit board eyelet 10 to securely grip and hold lead wires is an important advantage since it enables manufacturers using the eyelets to eliminate checking of the eyelet prior to solder dipping to be sure that the leads are properly positioned therein. Once the lead wires have been inserted in the eyelets the fingers secure the same in that position so that the lead is securely held as inserted during the soldering step.

After lead wires have been inserted in the eyelets as in Figure 7, the circuit board is solder dipped by exposing the bottom surface thereof to a pool or wave of molten solder. The molten solder is drawn up into the body of the eyelet by capillary action and flows through the notches 28 into the solder vee 58 formed between the flange 26 and the upper surface of the circuit board. Solder also flows directly from the solder bath into the vee 60 between the lower flange portion 34 and the lower surface of the circuit board. Figure 8 is a sectional view showing an eyelet after it has been solder dipped. The substantial mass of solder drawn into the solder vees between the circuit board surfaces and the eyelet flanges aids in preventing the hairline cracks common in ordinary eyelet connections with a circuit board where the head of the conventional eyelet is substantially flush with the surface of the circuit board. Thus by providing 45° flanges a more reliable solder connection is formed between the eyelet and the printed circuitry 46 on the circuit board.

The formation of most hairline cracks in conventional circuit board eyelet solder connections occurs during the cooling of the circuit board and eyelet after solder dipping. When a circuit board is dip soldered and comes into contact with the hot molten solder, it is heated to a high temperature. The coefficient of thermal expansion of organic circuit boards, such as those having a phenolic or epoxy base, is substantially greater than the coefficient of thermal expansion of the metal eyelet so that when the conventional circuit board and eyelet are cooled the decrease in thickness of the board is greater than the longitudinal shortening of the eyelet. After the board is removed from the solder bath the

solder between the flanges and the circuitry on the board solidifies to form a rigid solder connection therebetween prior to complete cooling of the board. As the circuit board and conventional eyelet continue to cool and shrink, each circuit path tends to be pulled away from the adjacent eyelet flange due to the greater contraction of the circuit board. The stresses resultant from the differential contraction of the conventional eyelet and circuit board frequently cause a separation or cracking betwen the eyelet flange and the circuit board. The cracking may occur either in the solder connection between the flange and the circuit board or in the circuit board adjacent the eyelet. Often the entire printed circuit pad surrounding the eyelet hole is lifted to form a crack between the printed circuitry and the board. Fractures may occur in the printed circuitry and result in broken or intermittent electrical connections which are difficult to locate and correct.

During cooling of the eyelet 10 according to the invention following solder dipping, the longitudinal pillar portions 36 which join flange 26 to flange portion 34 flex or deform slightly to relieve the stress caused by the differential thermal contraction of the board and eyelet. The flexing of the pillars allows the eyelet flange 26 to move with the surface of the circuit board during cooling, thereby preventing cracking of the type described which occurs in conventional structures. Because the difference in contraction of the circuit board and the metal eyelet during cooling is slight, the stress relief pillars 36 need flex or deform only slightly to provide the required stress relief and prevent cracking of the solder connection, circuit board, or circuit path.

In order to avoid cracking at the joint between the eyelet flange and printed circuitry the pillars 36 in eyelet 10 must collapse longitudinally to a slight extent in response to a compressive force of smaller magnitude than the tensile force required to cause separation or fractures at the solder connection between the eyelet flange and the circuit board. In conventional circuit board eyelets the cylindrical body portion is rigid and does not permit movement of the flanges with the circuit board during cooling and cracking results.

The stress relief pillars 36 adjacent the flange 26 have a circumferential extent less than the circumferential spacing between adjacent pillars for a longitudinal distance sufficient to permit the slight buckling or deformation required to prevent cracking.

The eyelet 10 provides stress relief to permit movement of the eyelet flanges with the circuit board under thermal shock. In thermal shock tests the circuit board is exposed to extremes in high and low temperatures. In one thermal shock test, soldered eyelets according to the invention were cooled to —65°C. for half an hour, warmed to 25°C. for five minutes, heated to 125°C. for half an hour, and then cooled to 25°C. for five minutes. The thermal shock test was repeated for five cycles. No cracks were found.

Eyelets having stress relief pillars similar to pillars 36 of eyelet 10 permit effective solder joints to be formed between circuitry on double-sided circuit boards even if the solder connection between the eyelet flange and the printed circuitry is not as strong as the solder connection formed when the flanges extend away from the board at 45°.

Notches 28 are provided around the circumference of the upper flange 26 to assure that sufficient solder flows into the upper solder vee 58 to make a reliable connection between the eyelet and the printed circuitry on the upper side of the circuit board. The lower solder vee 60 is exposed directly to the bath of molten solder so that there is no problem of assuring sufficient solder for making a connection with the printed circuit paths 46 on the lower side of the circuit board. The holes 20 and slits 18 which form the notches 28 are located at the middle of the circumferential extent of each finger 30 so as to prevent weakening of the joint 38 between the spring system 26—30 and the body 24 of the eyelet. It is important that the notch 28 extend to the top of the body 24 to assure capillary flow of solder through the notches and into the solder vee. As shown in Figure 8, solder dipping completely fills the interior of the eyelet so that a reliable electrical connection is established between the lead wire 48 and each of the printed circuit paths 46 carried by the circuit board 44.

Figure 6 illustrates typical uses of the eyelet in circuit board circuitry. The board 50 is provided with a number of printed circuit paths 52 and has a number of eyelet holes formed therein at the ends of the circuit paths in which eyelets 54 as described herein are secured. Circuit elements have been partially attached to the circuit board 50 so that two of the eyelets 54 are shown with lead wires inserted therein and another eyelet 54 is shown with the grounding lug of metal shield 56 inserted therein. When the board 50 is solder dipped, the shield 56 and the leads inserted in the eyelet 54 will be securely attached thereto by reliable solder joints.

It is important to note that an eyelet as described secures a lead wire or lead wires to a circuit board within the thickness of the circuit board. This is important because in modern circuitry there is a minimum of space available between the circuit board and adjacent parts of the circuit.

While we have illustrated and described a preferred embodiment of our invention, it is understood that this is capable of modification, and we therefore do not wish to be limited to the precise details set forth but desire to avail ourselves of such changes and alterations

as fall within the scope of the following claims.

WHAT WE CLAIM IS:—

1. A wire grip circuit board eyelet comprising a hollow cylindrical body shaped to be fitted within an eyelet hole extending through a circuit board, flanges on both ends of said body for holding the body within the circuit board hole, and a plurality of wire grip fingers cut out from said body and extending into the interior of said body in converging relationship with free ends of the fingers grouped together, said fingers being spaced around the circumference of the body in generally pyramidal relation so as to receive and hold a lead wire within the thickness of the circuit board.

2. A circuit board eyelet as in claim 1 wherein said fingers are connected to one of the flanges and the said one of the flanges is connected to the body so that the fingers and the said one of the flanges comprise a spring system for holding a lead wire in the eyelet body.

3. A circuit board eyelet as in claim 1 or 2 wherein said body includes a plurality of stress relief pillars spaced around the circumference of the body and connecting said flanges, said pillars being sufficiently flexible to permit contraction thereof during cooling following a soldering operation.

4. A circuit board eyelet comprising a hollow cylindrical body shaped to be fitted within an eyelet hole in a circuit board, and flanges at each end of the body for securing the eyelet in the circuit board hole; said body comprising a plurality of wire grip fingers cut out from the body and extending into the interior thereof in converging relationship with free ends of the fingers grouped together and a plurality of longitudinally extending and circumferentially spaced pillars, the circumferential extent of each pillar being less than the circumferential spacing between adjacent pillars for an axial distance sufficient to prevent movement of said flanges relative to the circuit board upon the occurrence of thermal shock.

5. A circuit board eyelet, substantially as hereinbefore described and as shown in the accompanying drawings.

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Sheet 1

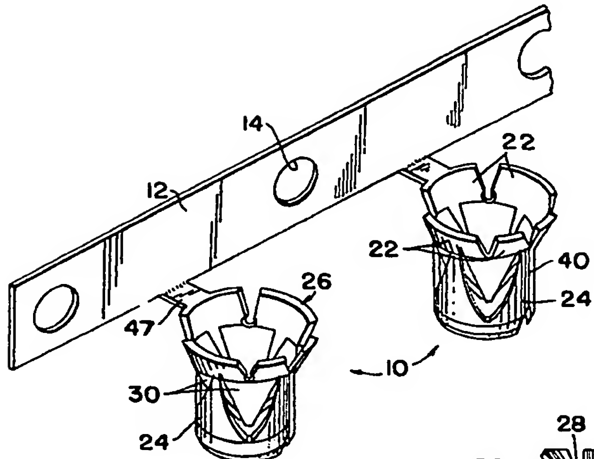

FIG.1

FIG.4

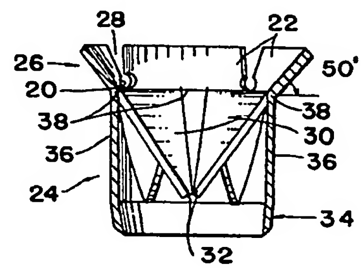

FIG.3

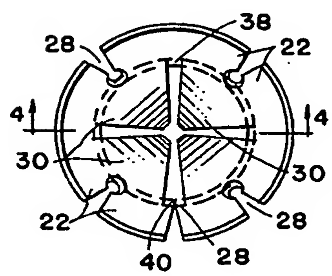

FIG.5

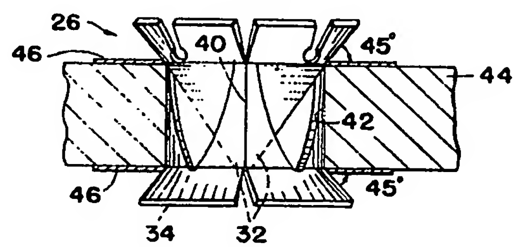

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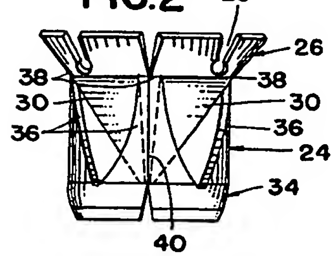
FIG.2



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Sheet 2

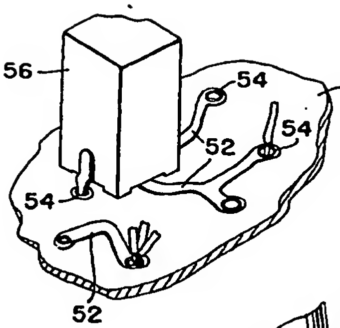
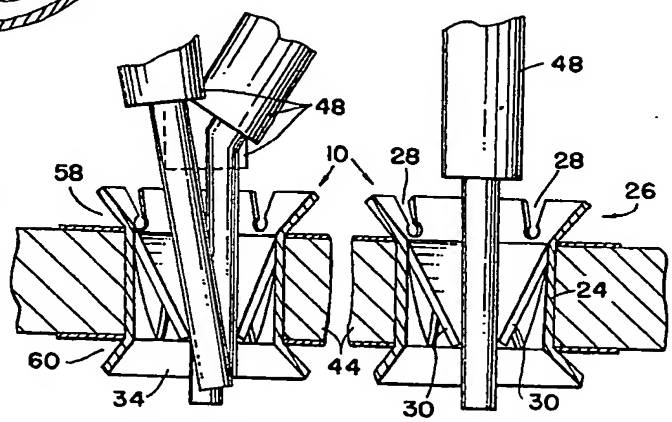


FIG.6

FIG.7



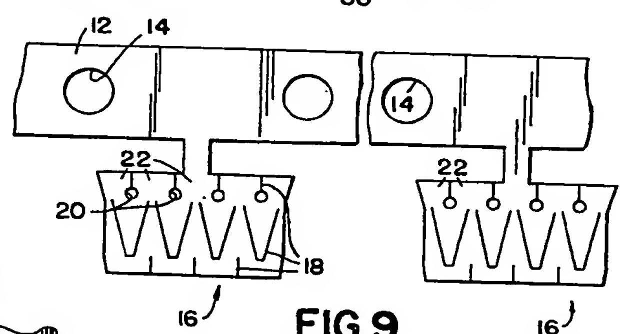


FIG.8

FIG.9